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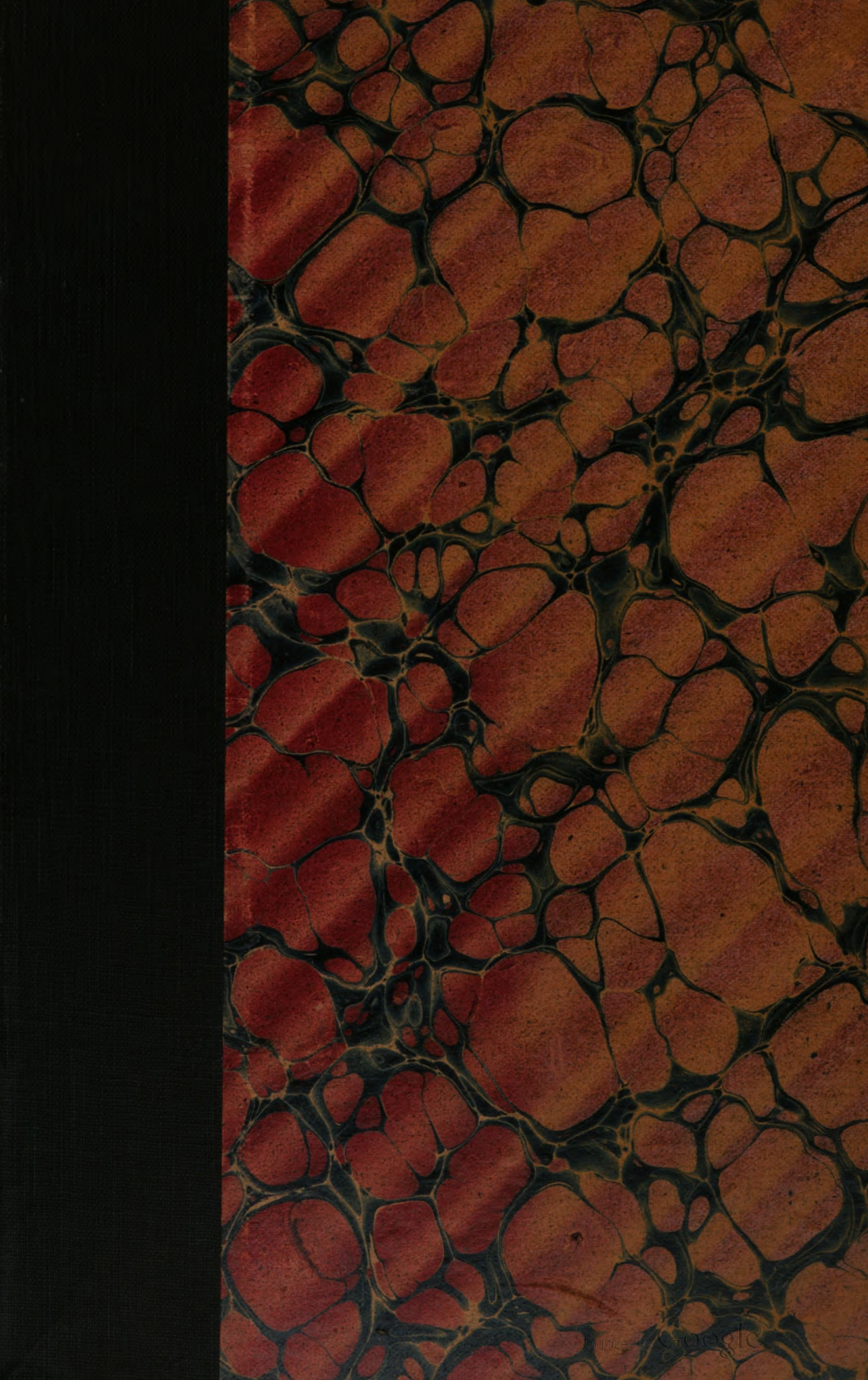
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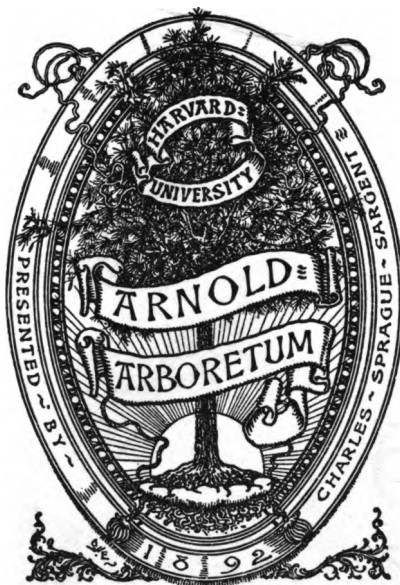
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DEPARTMENT OF THE INTERIOR.

REPORT

ON THE

PETRIFIED FORESTS OF ARIZONA.

BY

LESTER F. WARD,
PALEONTOLOGIST, U. S. GEOLOGICAL SURVEY.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

Red. July 1912
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., December 14, 1899.

SIR: I have the honor to transmit herewith a report by Prof. Lester F. Ward on the Petrified Forests of Arizona.

The request for the investigation and report came, at the instance of the Secretary of the Smithsonian Institution, from the Hon. Binger Hermann, Commissioner of the General Land Office. In order that the origin of the report may be fully understood by the Department, Professor Ward has included a copy of the correspondence leading to it.

Yours, respectfully,

CHAS. D. WALCOTT, *Director.*

The SECRETARY OF THE INTERIOR.

REPORT ON THE PETRIFIED FORESTS OF ARIZONA.

By LESTER F. WARD.

December 12, 1899.

SIR: In compliance with your instructions dated October 9, 1899, directing me "to visit what is known as the 'Petrified Forests of Arizona,' and, upon your arrival in Washington, render a detailed report of your investigations and observations concerning the same, including such information as may be of value touching the proposition to set aside the region embracing the Petrified Forests as a national park," I have the honor to make the following report:

In order to place the subject in as clear a light as possible, I will first give a brief historical account of the recent movement in favor of making a public reservation of the region embracing the Petrified Forests of Arizona.

In 1895 the legislative assembly of the Territory of Arizona adopted the following memorial to Congress:

HOUSE MEMORIAL No. 4.

To the Senate and House of Representatives of the United States of America in Congress assembled:

We, your memorialists, the eighteenth legislative assembly of Arizona, beg leave to represent to your honorable bodies:

First. That there is in the northern part of this Territory, lying within the borders of Apache County, near the town of Holbrook, a wonderful deposit of petrified wood commonly called the "Petrified Forest" or "Chalcedony Park."

This deposit or forest is unequaled for its extent, the size of the trees, and the beauty and great variety of coloring found in the logs.

The country 10 miles square is covered by the trunks of trees, some of which measure over 200 feet in length and from 7 to 10 feet in diameter.

Ruthless curiosity seekers are destroying these huge trees and logs by blasting them in pieces in search of crystals, which are found in the center of many of them, while carloads of the limbs and smaller pieces are being shipped away to be ground up for various purposes.

Second. Believing that this wonderful deposit should be kept inviolate, that future generations may enjoy its beauties and study one of the most curious and interesting effects of nature's forces,

We, your memorialists, most respectfully request that the Commissioner of the General Land Office be directed to withdraw from entry all public lands covered by this forest until a commission or officer appointed by your honorable bodies may investigate and report to you upon the advisability of taking this forest under the charge of the General Government and making a national park or reservation of it.

It is annually visited now by hundreds of scientific men and travelers from every State and country, and some such action by your bodies would preserve it from the vandalism it is now subjected to.

We would further state that at present there is no person living within the limits of the proposed park, so that no settlers will be disturbed by any such action on your part.

And be it resolved by the legislative assembly of the Territory of Arizona, That our Delegate in Congress be, and is hereby, instructed to use all honorable means to have some action taken by Congress to have this Chalcedony Park set aside and formed into a national park under the care and charge of the General Government.

Also that the secretary of the Territory be, and is hereby, requested to transmit a copy of this memorial to each House of Congress, our Delegate to Congress, and the United States Land Commissioner.

J. H. CARPENTER, *Speaker.*

A. J. DORAN, *President.*

[Indorsed.]

I hereby certify that the within memorial originated in the House and is known as House Memorial No. 4.

CHAS. D. REPPY, *Chief Clerk.*

Filed in the office of the secretary of the Territory of Arizona this 11th day of February, A. D. 1895, at 11 a. m.

CHAS. M. BRUCE, *Secretary of Arizona,*

By F. B. DEVEREUX, *Assistant.*

In June last the secretary of the Smithsonian Institution received the following letter from the honorable Commissioner of the General Land Office:

PETRIFIED FOREST, ARIZONA.

DEPARTMENT OF THE INTERIOR, GENERAL LAND OFFICE,

Washington, D. C., June 17, 1899.

SIR: I am in receipt of a certified copy of a memorial by the legislature of Arizona praying that certain lands in Apache County, Arizona, in the vicinity of the town of Holbrook, known as the "Petrified Forest," be withdrawn from entry with a view to creating a reservation or national park for the purpose of preserving the natural wonders and curiosities of the same.

I have the honor to request that you will kindly inform me whether the records of the Smithsonian Institution furnish any information respecting this locality indicating that the scenic features of the same are of such a nature as to render it desirable, in the interest of the public, to set these lands apart as a national park. I will be pleased to receive a full expression of your views on this subject, and also as to the importance of preserving the mineralized formations in that region.

Very respectfully,

BINGER HERMANN, *
Commissioner.

The SECRETARY OF THE SMITHSONIAN INSTITUTION.

To this letter the following reply was made:

SMITHSONIAN INSTITUTION,
Washington, D. C., July 7, 1890.

SIR: I have the honor to acknowledge the receipt of your communication of the 17th ultimo requesting information concerning the Petrified Forest near Holbrook, in Arizona, as well as an expression of opinion concerning the desirability of setting aside these lands as a national park, and beg to furnish the following statement:

The region near Holbrook, Apache County, Arizona, known as the "Petrified Forest," "Chalcedony Park," and "Lithodendron (stone trees) Valley," is of great interest because of the abundance of its beautiful petrified coniferous trees, as well as of its scenic features. The trees lie scattered about in great profusion, but none stand erect in their original place of growth as do many in the Yellowstone National Park. The National Museum possesses three splendid trunks collected there by Lieutenant Hegewald at the request of General Sherman.

The best popular account of this region is given by Mr. George F. Kunz, and is as follows:

"Among the great American wonders is the silicified forest, known as Chalcedony Park, situated about 8 miles south of Carrizo, a station on the Atlantic and Pacific Railroad, in Apache County, Arizona. * * * The locality was noticed in 1853 by the Pacific Railroad Exploring Survey. * * * There is every evidence to show that the trees grew beside some inland sea. After falling they became water-logged, and during decomposition the cell structure of the wood was entirely replaced by silica from sandstone in the walls surrounding this great inland sea.

"Over the entire area, trees lie scattered in all conceivable positions and in fragments of all sizes, the broken sections sometimes resembling a pile of cart wheels. * * * A phenomenon perhaps unparalleled and the most remarkable feature of the park is a natural bridge formed by a tree of agatized wood spanning a canyon 45 feet in width. In addition to the span, fully 50 feet of the tree rests on one side, making it visible for a length over 100 feet."

Lieutenant Hegewald writes:

"I rode down the valley to examine the thousands of specimens that lay scattered on each side of the valley along the slopes, which were perhaps 50 feet high; the valley of the Lithodendron, at its widest part, being scarcely a half mile. Along the slopes no vegetation whatever was to be seen, wood being very scarce; the soil was composed of clay and sand mostly, and these petrifications, broken into millions of pieces, lay scattered all adown these slopes. Some of the large fossil trees were well preserved, though the action of heat and cold had broken most of them in sections from 2 to 20 feet long, and some of these must have been immense trees; measuring the exposed parts of several they varied from 150 to 200 feet in length, and from 2 to 4½ feet in diameter, the centers often containing most beautiful quartz crystals."

Dr. Walter Hough, of the Smithsonian Institution, who has visited the park, writes as follows:

"In the celebrated Petrified Forest, which is some 18 miles from Holbrook, Arizona, on the picturesque Santa Fe Railroad, there are ruins of several ancient Indian villages. These villages are small, in some cases having merely a few houses, but what gives them a peculiar interest is that they were built of logs of beautiful fossil wood. * * * The prehistoric dwellers of the land selected cylinders of uniform size, which were seemingly determined by the carrying strength of a man. It is probable that prehistoric builders never chose more beautiful stones for the construction of their habitations than the trunks of the trees which flourished ages before man appeared on the earth.

"This wood agate also furnished material for stone hammers, arrowheads, and knives, which are often found in ruins hundreds of miles from the forest."

This "wood agate" or "wood opal" is now cut and polished into floor tiling, mantels, clock cases, table tops, paper weights, etc. The silver testimonial to the French sculptor Bartholdi, made by Tiffany & Co., had for its base a section of this wood agate.

Prof. Lester F. Ward, an eminent paleobotanist, who, while officially attached to the staff of the United States Geological Survey, also holds the position of associate curator in the National Museum, expects to visit the Pacific coast this summer, and may return by the southern route. He tells me that if you so desire he would be pleased to visit the region in question for the special purpose of procuring further information regarding the features covered by your inquiry.

In conclusion I would say that all with whom I have consulted are agreed that the "Petrified Forest," or "Chalcedony Park," of Apache County, Arizona, should be preserved as a public park for the benefit of the American people. In no other area is there such a profusion of highly colored stone trees. Fossil wood is scattered over a very great area of Arizona, but the densest portion and chief place of interest is "Chalcedony Park," an area of less than 5 miles square. This region is about 20 miles south of Carrizo station.

A list of papers relating to the Arizona forest trees is appended.

Very respectfully,

RICHARD RATHBUN,
Acting Secretary.

Hon. BINGER HERMANN,
*Commissioner General Land Office,
Department of the Interior,
Washington, D. C.*

Growing out of the paragraph containing my offer to visit the locality, and a personal call at the General Land Office, the Hon. W. A. Richards, assistant commissioner, in the absence of the Commissioner, wrote me as follows:

DEPARTMENT OF THE INTERIOR, GENERAL LAND OFFICE,
Washington, D. C., August 19, 1899.

DEAR SIR: As requested by you yesterday, I have written a letter to Hon. Charles D. Walcott, Director of the Geological Survey, requesting that you be instructed to visit the "Petrified Forests" of Arizona, in order that you may make report as to the advisability of setting that locality apart as a national park.

I also have had prepared a copy of the memorial of the Arizona legislature relating to the subject, which I inclose herewith.

Very truly, yours,

W. A. RICHARDS.

Prof. LESTER F. WARD,
Paleontologist, Geological Survey.

Owing to your absence in Canada and my departure for the Pacific coast, where I remained during September and October, I did not receive your instructions, above quoted, until the middle of October. At about the same time I received the following letter from the secretary of the Smithsonian Institution:

SMITHSONIAN INSTITUTION,
Washington, October 13, 1899.

The Smithsonian Institution takes pleasure in introducing to its friends Prof. Lester F. Ward, Paleontologist of the United States Geological Survey, and associate curator

in the United States National Museum, who visits the region of the fossil forests in Arizona at the instance of the Hon. Binger Hermann, Commissioner of the General Land Office, with a view to obtaining information for the use of the Commissioner in connection with a request of the legislature of Arizona that certain lands in the vicinity of Holbrook, known as the "Petrified Forest," be set aside for a national park.

Any courtesy which may be extended to him will be duly appreciated by the Institution.

S. P. LANGLEY, *Secretary*.

Equipped with these instructions and credentials I left San Francisco on November 1, 1899, and proceeded direct to Arizona. After a week of general investigation in the western part of the Triassic terrane, I arrived at Holbrook on the 9th and entered the special area of the petrified forests on the 10th. I went over the ground with considerable thoroughness and visited about all the localities of interest, taking full notes of the scenic, geologic, and scientific features.

SCENIC FEATURES.

With regard to the first of these, viz, the scenic aspect, I can safely say that it has never been exaggerated by any who have attempted to describe this region. The pictures given in the letter of the Assistant Secretary of the Smithsonian Institution, above quoted, are not overdrawn, and the more or less glowing descriptions of Möllhausen, Marcou, Newberry, and other early explorers fall far short of what might be truly said from this point of view. These petrified forests may be properly classed among the natural wonders of America, and every reasonable effort should be made not only to preserve them from destructive influences but also to make their existence and true character known to the people.

Some of the most important considerations that may be urged in favor of the importance of this region compared with other petrified forests rest upon its geological relations. In the first place, it is much more ancient than the petrified forests of the Yellowstone National Park, of certain parts of Wyoming, and of the Calistoga deposits in California. These latter are of Tertiary age, while the Arizona forests belong far back in Mesozoic time, probably to the Triassic formation. The difference in their antiquity is therefore many millions of years. Scattered blocks of silicified wood do indeed occur in the Trias at other points, but this is the only region in which they are in such abundance as to deserve the name of a petrified forest.

In the second place, there is no other petrified forest in which the wood assumes so many varied and interesting forms and colors, and it is these that present the chief attraction for the general public. The state of mineralization in which much of this wood exists almost places them among the gems or precious stones. Not only are chal-

cedony, opals, and agates found among them, but many approach the condition of jasper and onyx. The degree of hardness attained by them is such that they are said to make an excellent quality of emery.

Perhaps the most prominent of all the scenic features of the region is the well-known Natural Bridge, consisting of a great petrified trunk lying across a canyon and forming a footbridge over which anyone may easily pass. For reasons that will be obvious, the full treatment of this feature is deferred to a more appropriate place.

LOCATION OF THE PETRIFIED FORESTS.

It should be understood that petrified or silicified wood occurs in great quantities throughout the Triassic terrane of Arizona, New Mexico, and Utah, and there are hundreds of places where the logs are massed together or even piled one upon another; but the particular region known as the "Petrified Forest of Arizona" lies in the area between the Little Colorado and the Rio Puerco, 15 miles east of their junction, 17 miles east of Holbrook, and 6 miles south of Adamana station on the Santa Fe Pacific Railroad, which measurements terminate at the outer edge of the area on the west and north sides. It is about 8 miles square, and falls chiefly within township 17 north, range 24 east, but extends a short distance on the south into township 16 north, and on the west into range 23 east.

This region consists of the ruins of a former plain having an altitude above sea level of 5,700 to 5,750 feet. This plain has undergone extensive erosion to a maximum depth of nearly 700 feet, and is cut into innumerable ridges, buttes, and small mesas, with valleys, gorges, and gulches between. The strata consist of alternating beds of clays, sandstone shales, and massive sandstones. The clays are purple, white and blue, the purple predominating, the white and blue forming bands of different thickness between the others, giving to the cliffs a lively and pleasing effect. The sandstones are chiefly of a reddish brown color and closely resemble the brownstone of the Portland and Newark quarries, or the red sandstone of the Seneca quarries on the Potomac River and at Manassas in Virginia, but some are light brown, gray, or whitish in color. The mesas are formed by the resistance of the massive sandstone layers—of which there are several at different horizons—to erosive agencies, and vary in size from mere capstones of small buttes to tables several miles in extent, stretching to the east and to the northwest.

The drainage of the area is to the south, and in the middle of it, having a nearly due southern course, but winding much among the buttes, is the arroyo which has been mistaken for the famous Lithodendron Creek, so named by Lieutenant Whipple in 1853.¹ It is dry most of the year, but has a gravelly bed, often 20 feet in width, and

¹ See Twentieth Annual Report U. S. Geological Survey, Part II, p. 324.

if holes are dug in this gravel to a depth of 4 or 5 feet water will accumulate and stand in them.

The valley of this creek is narrow in the northern and central parts of the area, and there are several short branches or affluents, but at the southern end it broadens out, and its rugged, spurred, and canyoned slopes are highly picturesque. Here is located its principal petrified forest, and this is the region that has been characterized by some as Chalcedony Park. The petrified logs are countless at all horizons and lie in the greatest profusion on the knolls, buttes, and spurs, and in the ravines and gulches, while the ground seems to be everywhere studded with gems, consisting of broken fragments of all shapes and sizes and exhibiting all the colors of the rainbow. When we remember that this special area is several square miles in extent some idea can be formed of the enormous quantity of this material that it contains.

Although much fossil wood occurs throughout the whole region, as above delimited, still for several miles to the north of this Chalcedony Park it is less abundant, and it is not until the northern end of the area is reached that another center of accumulation occurs. This lies between two mesas in a valley that opens out upon the general plain which stretches north to the Rio Puerco. It is much smaller in extent than the southern park, but substantially the same general features are presented.

There is still a third center of accumulation, called the "middle forest," which lies some 2 miles southeast of this last, and extends to the eastern margin of the general region. It occupies the western slope of the table-land on the east, and is very extensive, stretching a mile or more in a north and south direction and having a width of half a mile in places. It presents many interesting novelties.

GEOLOGICAL CONSIDERATIONS.

All the petrified forests thus described are, geologically speaking, entirely out of place, and the trunks bear every evidence of having dropped down to their present position from a higher horizon in which they were originally entombed and from which they have been subsequently washed out. Nor is their original position to be discovered by ascending the several mesas included in the area, although some of these rise 400 feet above the bed of the above-mentioned creek. It is not until the still higher plateau is reached which bounds the whole region and lies more than 700 feet above the valley that the stratum is at last found which actually holds the fossil wood. A geologist might therefore traverse the entire area from north to south, visit all three of the principal forests, and go out with the impression that everything was out of place and with no correct idea of the true source of the fossil

wood. Even on the east it would be difficult to settle this question on account of the paucity of the trunks in that direction, but it could doubtless be done by prolonged and careful search. On the west side, however, and directly west of the southernmost area, the plateau is only about 2 miles wide and has a western escarpment with another valley extending both south and west of it. This plateau or elongated mesa is highest on its western side, rising to the 5,750-foot contour line immediately above the escarpment, and here is exposed a fine series of petrified trunks fringing the mesa, with many weathered out on the slope or rolled down into the valley below. A few feet below the actual summit is a bed some 20 feet thick of coarse, gray, conglomeratic, cross-bedded sandstone, at many places in which were found firmly embedded logs and branches of the petrified wood, often projecting from it in the cliffs and clearly in place. This, then, is the true source of the fossil wood, and after several days study on all sides of the area I became convinced that no other layer holds any of it, at least in this region.

This bed was found at nearly all points where the requisite elevation can be attained, but the petrified logs do not occur in the same abundance throughout. They are massed or collected together in groups or heaps at certain points, and may be altogether absent at others. From their great abundance in the three areas above described, which may be called the upper, lower, and middle forests, respectively, but in all of which they are out of place and lie several hundred feet below their proper position, it must be inferred that the stratum which holds them was especially rich, and the trunks must have lain in heaps upon one another. This bed may have been considerably thicker in these areas than it is farther out on the margins, where it is now found in place.

Only at two points within the general petrified forest area did I find remnants of this bed which had not been broken down and disintegrated. One of these is at the extreme northern end, half a mile northeast of the upper forest. Here there is a small mesa, which lies at an elevation of nearly 5,700 feet, or about 400 feet above the valley which contains the upper forest. It is isolated and its nearly flat top, which is approximately circular, is about half a mile in diameter. The coarse conglomeratic sandstone stratum, 20 to 30 feet in thickness, occupies the summit of this mesa and is often hardened into rock, but in all essential respects it is identical with that of the elongated mesa on the southwest side of the area above described. The petrified wood is less abundant here, but sufficiently common, and is embedded in and often projects from the sandstone ledges.

The Natural Bridge.—Besides the fact that this bed lies wholly within the petrified forest area, there is another important circumstance which serves to give it special prominence. One of the most celebrated objects in this entire region is the well-known "Natural

Bridge," mentioned by so many travelers and referred to in the documents quoted at the beginning of this report, consisting of a great petrified trunk lying across a canyon and forming a natural footbridge on which men may easily cross. This occurs on the northeast side of the above-mentioned mesa near its rim, and the bed in which it lies is the coarse sandstone which holds all the petrified wood. The Natural Bridge, therefore, possesses the added interest of being in place, which can be said of very few of the other petrified logs of this region.

It was observed in the southwestern exposure and at other points that all the petrified logs and blocks lying in the sandstone or only recently washed out of it are surrounded by a coating of the sandstone firmly cemented to the exterior. The absence of this coating from most of those in the principal forests is due to their long exposure to climatic influences which ultimately disintegrate and detach the sand rock adhering to them and strip them clean to the body of the trunks themselves. That this process requires ages of time is proved by the fact that the Natural Bridge is still coated over a large part of its surface by the remains of the cemented sand rock in which it was once completely imbedded. This is true chiefly of the lower portion, and farther up the trunk it has nearly all disappeared. The trunk is in an excellent state of preservation and is complete to the base, where it is abruptly enlarged and shows the manner in which the roots were attached. This portion still lies partially buried in the sandstone, which is the same in character as that which still adheres to the lower 20 feet. The canyon or gulch has a due north direction and is very precipitous, beginning only 200 yards above the bridge and rapidly broadening in its descent. At the point where the bridge crosses it is about 30 feet wide, but the trunk lies diagonally across and measures 44 feet between the points at which it rests on the sides of the canyon. The angle is nearly 45° , and the tree lies with its roots to the southeast and its top to the northwest. The canyon is here about 20 feet deep, and from its bottom and slopes several small trees are growing, some of which rise considerably above the bridge. The trees are mostly cedars, but there is one cottonwood (*Populus angustifolia*). The root is quite near the brink of the canyon, but rests on a solid ledge for a distance of 4 feet, so that there is no probability that in this dry region it will be endangered by further erosion. The total length exposed is 111 feet, so that more than 60 feet of the upper part lie out on the left bank of the canyon. At about the middle of the canyon, and above where the coating of sandstone still adheres, it measures 10 feet in circumference, giving a diameter of over 3 feet. At the base it is now 4 feet in diameter, but the thickness of the incrustation is not exactly known. At the extreme summit the diameter is reduced to 18 inches. As in the case of practically all the petrified logs of the region, there

are no indications of limbs or branches at the top. The significance of this fact will be noted later.

A conspicuous characteristic of all the petrified trunks, not only of this area and of the general Triassic terrane of Arizona and New Mexico but of all petrified forests, is their tendency to break across into sections or blocks of greater or less length. All travelers have remarked this, and the sketches given by Möllhausen and in the Pacific Railroad Reports show them thus divided. Some observers have noted the fact that the Natural Bridge has several of these transverse cracks, and all the good photographic views of it show them. I counted four, but most of them seem to be as yet only partial and do not probably extend entirely through the trunk. There is one, however, near the left bank of the canyon which has the appearance of doing so, and the trunk is probably only kept from parting at this point by the mechanical adjustment which causes the adjacent faces to perform the office of a keystone to an arch. Any considerable shrinkage due to climatic or other causes would overcome this influence and the entire bridge would crash to the bottom of the canyon and roll down the escarpment in a number of huge segments.

An examination of the relations of the Natural Bridge to the gulch which it spans shows clearly that the trunk was primarily entombed in the sandstone bed covering this entire region, and that, with the progress of erosion which ultimately carried away the entire plain to the north, as well as in other directions, leaving this small mesa, it was at last exposed, and lay for a great period near the rim of the escarpment. At first it was only partially buried and later came to lie on the surface of the ground. As the land rises somewhat to the south of it, rills were formed above, and in times of floods or heavy rain it obstructed the flow of the water, forming a sort of dam. The water lying against it long after it had ceased to overflow it, tended to disintegrate the rock upon which it lay, until eventually it found its way through beneath it at some one point. The smallest opening of this nature would soon become a free passage for the water, and a simple continuation of this process of local erosion would ultimately result in the formation of the entire gorge as it exists to-day.

The other case which I observed of the presence of the conglomeratic sandstone within the general petrified forest area occurs near its center, about midway between the upper and lower forests along the narrow portion of the valley of the creek described above, on both sides of the canyon and near the level of its bed, at an altitude of about 5,300 feet. The exposure was typical in all respects, and logs were seen projecting from the canyon walls, from one of which specimens were collected. As this exposure is 400 feet below that in which the Natural Bridge occurs and 450 feet below that on the southwestern mesa, its presence there can be accounted for only on one of two hypotheses, either that of the

existence of another exactly similar stratum at this horizon or that of a fault, or, what would amount to the same thing, a slide or slipping down of a large block of the uppermost beds in such a manner as not to disturb their stratigraphical arrangement.

The first of these hypotheses is rendered improbable by the fact that a careful study of the beds at the same horizon in other places revealed no such stratum, and it could scarcely be so local as not to be found elsewhere. The second hypothesis seems every way probable, as in such a much-disturbed region it would be easy for the erosive agencies to undermine a small outlier or mesa and cause it to sink down intact to a lower level. The question, however, requires more detailed investigation than I was able to give to it.

Leaving this phenomenon out of the account, therefore, and considering the two exposures, in which there is no question as to their natural position, we may use them as a means of determining whether the strata have any dip, and to some extent in ascertaining the amount and direction of the dip. The topographic map has a 250 feet contour interval, which is too large to be employed with any very great accuracy, and an aneroid can hardly be depended upon for measurements made six hours apart, as had to be done in this case, but as nearly as I could judge from all sources of information the Natural Bridge mesa seems to be between 50 and 100 feet lower than the southwestern mesa. As the distance from the one to the other is about 5 miles, the dip to the northeast is somewhere between 5 and 10 feet to the mile. As, however, the strike was not accurately determined, there is no certainty that this is the true dip of the strata, and more precise observations on a much larger scale will be necessary to settle this question.

Although there is no longer any question as to the true stratigraphical position of these profuse vegetable remains, there are many facts which stand in the way of the supposition that the trees actually grew where we now find them. Several accounts¹ profess that stumps occur erect with their roots in the ground, showing that they grew and were buried and petrified on the spot, but I was unable to confirm any such observations, and on careful inquiry of residents of the country, who had minutely examined every part of the area, I was unable to learn of a single indisputable instance of such an occurrence. The only trunk that I saw standing on end was one that was inverted and had its roots high in air! In fact, from the nature of the case, as I have just shown, there would be no use looking for any such phenomenon in any of the principal fossil forests, since they all lie from 100 to 400 feet below where they were originally deposited. It is only in the

¹ Tagebuch einer Reise vom Mississippi nach den Küsten der Südsee, von Balduin Möllhausen. Leipzig, 1858, p. 300.

Résumé explicatif d'une carte géologique des États-Unis et des provinces anglaises de l'Amérique du Nord, etc., par Jules Marcou. Bulletin de la Société Géologique de France, 2^e sér., Vol. XII, 1856, p. 871. Repeated in Geology of North America, etc., Zurich, 1858, p. 13.

beds of coarse sandstone that hold them, therefore, that the evidence need be sought. This I did with the utmost care, but even here I found no example of an upright trunk.

In this, as I was glad to learn after my return on looking the matter up, I was only confirming the observations of Dr. J. S. Newberry, made in 1858 and published in 1861.¹

Although it is easy to find petrified limbs and small twigs among the other objects, still these occur sporadically and accidentally at any and all points. They are no more likely to be found beyond the termination of the tall trunks than anywhere else, as would be the case if the trees lay near where they grew. In fact, it happened that I never found small twigs in this position, although I searched in hundreds of cases. I found no petrified cones, but I heard vague reports of their having been found. It would be strange if none were preserved in such a vast mass of trunks of cone-bearing trees.

Finally the great abundance of the material would seem to negative the idea that it could have all grown on the same area. Even if every tree had been preserved, there are places where it would have been impossible for them to stand as thickly as they lie on the surface, not to speak of the space that trees in a forest require in order to thrive, as these trees evidently did thrive. And while there is now no place where they lie so thickly in the original bed of sandstone, still, even here they are not only all prostrate, but lie in little collections and huddles quite differently from what should be expected if they were precisely where they grew.

The preservation of a forest in situ with the trunks erect could scarcely take place except by some sudden, commonly eruptive agency. Such agencies have undoubtedly operated in the preservation of the petrified forests of the Yellowstone Park and of others that I have visited in Wyoming and elsewhere, in which the stumps and sometimes tall trunks do stand in position with their roots in the ground, but in the region under consideration there are only faint indications of eruptive agencies, certainly not sufficient to account for the phenomena.

The indications therefore all point to some degree of transportation of this material by water antecedent to petrification, and the great

¹ Report upon the Colorado River of the West, explored in 1857 and 1858, by Lieut. Joseph C. Ives, Washington, 1861, 4°. Part III. Geological Report, by J. S. Newberry, p. 80.

Dr. Newberry's statement is as follows:

"I examined these specimens with some care to determine, if possible, whether they had grown on the spot, as those of *Lithodendron* Creek are supposed to have done by the members of Captain Whipple's party, or whether they had been transported to their positions. In all that came under my observation, I failed to find any evidence that they had grown in the vicinity. All the trunks are stripped of their branches and exhibit precisely the appearance of those transported to some distance by the agency of water. In confirmation of this view I should also say I found in the marls, with the entire trunks, rounded and water-worn fragments of wood, in some instances silicified and in others converted into lignite.

I gathered the same impression from all the collections of silicified wood which I observed in this formation in western New Mexico, viz: that all had been transported, but not far removed from their place of growth."

amount of it at this particular place argues for the existence of such a condition as would arrest the process and cause the floating logs to accumulate in masses, as often happens in great eddies or the deltas of rivers. The character of the bed in which they occur further supports this view. The coarse sand and gravel, highly favorable to the process of silicification, denotes the proximity of the land, and the crossbedding bears witness to the existence of rapid and changing currents. As this stratum occupies the highest elevations in this region, the nature of the overlying beds is not revealed, and the question whether the period was followed by one of general subsidence can only be settled by a study of the higher plains lying some distance to the east and north, but it is probable that the bed sank and that finer deposits ultimately buried it at the bottom of the Mesozoic sea, there to remain until the Tertiary epeirogenic movement raised the entire country from 5,000 to 6,000 feet above sea level.

PRESERVATION OF THE PETRIFIED FORESTS.

It will be obvious from the above that the Petrified Forests of Arizona constitute an object of interest to all people of culture from both the æsthetic and the scientific points of view, and that the immediate region here considered embraces the most striking features that they anywhere present. As stated in the memorial of the Territorial legislature to Congress, and as confirmed by my inquiries and admitted by all, these natural wonders are attracting thousands of visitors annually, most of whom are drawn there by mere curiosity. This characteristic of human nature, however aimless it may sometimes seem, and however destructive it may often be, forms, under a broader culture, the true foundation of all discovery and progress. It needs encouragement and direction rather than suppression, and the policy should be to increase the attractions and to facilitate access to this as well as other extraordinary natural objects; but at the same time the destructive effects, especially such as tend to reduce the interest, mar the beauty, or lessen the instructiveness of the facts, should be prevented by every proper means.

No one denies that visitors to this region usually carry away with them as much as their means of transportation will permit, but this consists usually, of course, of the smaller objects that lie in such profusion on the ground. At first view it might seem that the immense quantity of such objects makes it impossible that any appreciable impression can ever be made upon the whole mass in this way. This is the same kind of reasoning, or rather unreasoning, that has led to the virtual extinction of the buffalo, and which threatens to exhaust the sources of natural gas; but the class of persons known as "relic hunters" is very large, and the number who will in future visit the

Petrified Forests is destined greatly to increase. They usually carry with them some concealed tools or instruments, and with these they are perpetually breaking off pieces of objects of which they wish to carry away souvenirs. In this way the finest trunks are being hacked to pieces and disfigured. For example, there are several places on the Natural Bridge where this process has been going on, until quite large holes or unsightly cavities have been dug in the upper side of the trunk. The small chips and blocks that lie detached on the ground in such quantities vary greatly in form and coloration, and it is, of course, always the most symmetrical and brilliant that are first picked up, and these will eventually be so culled out that only the plainer, unattractive pieces will be left.

It is said that a useful purpose is subserved by sending specimens of the petrified wood to educational institutions. This might no doubt be true under proper regulation, especially if the specimens were duly labeled and authenticated and placed in properly arranged cabinets, to be explained by the teacher. This will scarcely be accomplished by permitting the free access of all parties with the right to carry away specimens at will.

Besides this piecemeal method of making inroads upon the treasures of the Petrified Forests, there are ways in which the work may be and to some extent has already been accomplished on a much larger scale. Many years ago the firm of Drake & Co., of Sioux Falls, undertook the work of manufacturing table tops, mantels, clock cases, pedestals, paper weights, and other articles of furniture and decoration out of these sections of agatized wood, by polishing the smooth surfaces and cutting them into the desired forms. I understand that Tiffany & Co., of New York, obtained through this company the beautiful pieces used by them for such purposes. I visited their house at the time they were engaged in this work, and through the courtesy of Mr. George F. Kunz was shown some of the raw material that they then had in hand, consisting of several sections of immense trunks, of the most brilliant colors. While in the park the present season my teamster informed me that he was employed for a long time hauling these trunks out of the upper forest to Carrizo station. Although, according to all accounts, many carloads of it were shipped to the East, he said that there was a larger quantity left at the station that was not shipped than all that was removed at that time. As scarcely any of this remains at the station now, I asked him what had become of it, and he said it had been carried off little by little by anybody that wanted a piece.

At a later date the Armstrong Abrasive Company, of Denver, conceived the idea of grinding up these trunks to make emery, for which they are said, from their extreme hardness, to be an excellent material. They had a plant for this purpose in Chicago, which they moved

to Arizona, and it is now at Adamana station, the nearest point to the Petrified Forests on the Santa Fe Pacific Railroad. I was informed that the plant never was put into operation, and on inquiring the reason I was told that a Canadian company at about the same time commenced the manufacture of emery and reduced the price to a point below that at which it would be profitable to grind up the Arizona wood. So small a business consideration prevented the somewhat wholesale denudation of the Petrified Forests for commercial purposes. What the next inducement in the same direction may be can not be predicted, but there is always the danger that some powerful mercantile interest may do its destructive work.

LOCAL OPINION RESPECTING THE PROPOSED RESERVE.

In making the investigations above recorded, in compliance with your instructions, I endeavored to preserve a wholly neutral attitude on the general question as to the advisability of reserving the Petrified Forests as a national park, and, as a matter of fact, the subject presented many practical difficulties which I was not and am not now able to remove. However clear the general proposition may be that so important a scenic feature and so great a natural wonder ought to be cared for and preserved intact for the enjoyment and instruction of the people, the question as to how this can best be accomplished is somewhat complicated and requires for its solution practical rather than scientific qualities of mind and considerable familiarity with its popular aspects. I therefore considered it my duty to feel, as it were, the local pulse on the subject, and I lost no opportunity to obtain the opinion of leading citizens of Arizona. As a result of my inquiries in this direction I was able to make the generalization that within the Territory the acquaintance with and interest in the project were inversely proportional to the distance of the parties from the region to be affected. In the immediate or close vicinity scarcely any one had heard of the action of the Territorial legislature, and almost no one evinced any interest in the matter. Such was the condition of things in Holbrook and Winslow. At Flagstaff and Williams there was more of both information and interest. I did not go to Prescott nor Phoenix, but I met and heard of people in both these places who were familiar with the movement and deeply interested in its success. First and foremost among these should be mentioned Governor Murphy, whose letter on the subject I give in full below. I chanced to meet his brother, Mr. Frank M. Murphy, of Prescott, on the train while returning from the field, and we had a conversation on the subject, freely discussing all the principal points. He presented a number of cogent arguments in favor of the project, as set forth in the memorial.

At his suggestion, as well as with the advice of several other interested parties whom I met in the Territory, I addressed a letter to Governor Murphy on my return to Washington, asking him for a full expression of his views. In my letter to him I said among other things:

You will understand that my instructions do not indicate the nature of my report, which is expected to be entirely disinterested upon the question of the advisability of the action asked for by the memorial, but I have not concealed my personal interest in the preservation of this wonderful natural feature of the country, and while my investigations in the immediate locality, which were quite thorough, did not reveal any blameworthy action on the part of any particular individuals, still, with the rapid growth of the Territory and the increasing travel and interest in all such matters in this country, it is obvious that it can not be long before something will need to be done if the scenic features of this region are to be preserved. It is not perfectly clear to me in what way the Government would accomplish this purpose if the reservation were made, and I doubt whether it could be successfully done without the active cooperation of the people of Arizona, and this would have to be something more than could be expected of the local residents of that district.

I therefore write you in the hope that you may freely express your views on the general subject, so that I may avail myself of them in my report. From the geological standpoint I, of course, have all the data necessary for the report, as I spent sixteen days in that general region constantly in the field; but upon the practical question of what the Government should do in case the district is set apart, and especially after such action, I do not feel fully competent to advise and need the assistance of practical public-spirited people, to whom the subject comes nearer home.

He replied promptly to this letter as follows:

OFFICE OF THE GOVERNOR,
Phoenix, Arizona, November 28, 1899.

DEAR SIR: Your letter of November 23, in reference to the so-called Petrified Forest in northern Arizona, received. I know of no way the Government can preserve this natural curiosity except by having it set aside as a reserve and appointing a keeper to protect it against vandalism.

As you probably observed when there, it is not attractive in the way of natural scenery. It seems to me peculiarly valuable for scientific purposes. I shall be glad to cooperate in any appropriate way for the preservation and protection of the so-called forest, but much expense on the part of the Government in creating a reserve for scenic purposes does not seem to me justified. I do not apprehend that any very large proportion of the agatized material will be removed. Some of the wood has been removed and polished and was exhibited at the World's Fair in Chicago, and I understand an exhibition of it is proposed at Paris next year. I do not think any injury can result from small quantities of the material being used in this way. As the mineral is scattered over the sands in large quantities, some of it covered at considerable depth, and there being a lack of water there for improving the grounds, I do not know of anything that can be done except to guard against its removal, and it is likely that your personal observation will enable you to make the most appropriate recommendations to the Department in regard to the matter.

Yours, very truly,

N. O. MURPHY, *Governor.*

MR. LESTER F. WARD,

Paleontologist, United States Geological Survey, Washington, D. C.

I also wrote to Mr. Thomas Bunch, of Flagstaff, member of the legislative committee of Arizona, whom I did not meet there, but who, as I learned from a friend of his, Mr. George W. Sturtevant, of Chicago, had taken a special interest in the Petrified Forests. Mr. Bunch also replied promptly and his letter is altogether to the point:

FLAGSTAFF, ARIZONA, *November 28, 1899.*

DEAR SIR: Yours of 23d instant received. I would like to see the Petrified Forest preserved. If it can be preserved by setting it aside as a national park I hope it may be done at an early date. I have known it and been there often for the past sixteen years, and every time I go I can see the traces of the vandal. Inside of twenty years from now there will be but little left of interest. However, I would be pleased to see some of the best specimens placed in our public institutions, and for that purpose I would permit a limited amount to be removed. I desire to have brought here a nice section and to place it in the Northern Arizona Normal School, and for like purposes I think it advisable to allow the removal. I hope the Government will see that it is not further made the place of amusement with explosives and that no more is blown up with powder.

Yours, truly,

THOS. S. BUNCH,

Member Legislative Committee of Arizona.

LESTER F. WARD, Esq., *United States Geologist, Washington, D. C.*

From all this it will be seen that leading citizens and prominent public men in Arizona are sincerely desirous of preserving this interesting spot from vandalism and wanton destruction, and that many of them think that this can best be done by making it a national reserve and appointing the proper guardians to take charge of it. As they show, the expense of this need not be large. A single mounted ranger, such as now patrol the forest reserves of the Colorado plateau, would probably be adequate to this purpose for some time to come.

As nearly all tourists and visitors must approach the Petrified Forests by way of the Santa Fe Pacific Railroad, it is clearly to the interest of that road that they be made as attractive as possible, and there is no doubt that the officers of the road will gladly cooperate with the Government in this matter. A few years ago the nearest railroad station was Corriso, which is some six miles west of north of the upper forest. The inconvenience of this was apparent to the railroad authorities, and they have recently established a station due north of the forests, only 7 miles from the nearest margin and about 8 miles from the Natural Bridge. This is the station of Adamana, the name being modified from that of the only person living there, Mr. Adam Hanna, upon whom now falls the duty of conducting parties to the Petrified Forests. Mr. Hanna derives considerable revenue from this source, especially as it is usually necessary for parties to stay over night, and he takes care of them. But his house is not convenient to the station and is not adapted for a hotel, and as the number of visitors increases it will become necessary to provide more ample accommodations. There will need to be a hotel with civilized conveniences, and

it will eventually be to the interest of the railroad company to provide such, as also suitable conveyances and guides.

The importance of the cooperation of the railroad in this matter struck me so forcibly that I did not consider my mission completed until I had made some inquiries along this line. In returning from the field, therefore, on my arrival at Chicago I called on President E. P. Ripley, of the Santa Fe system, to obtain his views. It chanced that Mr. Frank M. Murphy, whom I had met on the train, as above mentioned, was in Mr. Ripley's office at the time I called, and quite a discussion of the general project was entered into. Mr. Ripley expressed a willingness to cooperate with the Government in the matter to the fullest extent in case the proposed action was taken. He was much interested in certain of the scientific aspects of the case that I presented. Mr. Murphy very correctly pointed out that the fact of setting the district apart by the Government as a national park would do more than anything else that could be done to make it known to the public, thus constituting a legitimate advertisement for the road, and working in the joint interest of the company and the people.

RECOMMENDATIONS.

After all that has been said it scarcely seems necessary to make specific recommendations. I have endeavored to set forth the facts somewhat fully, and they will doubtless carry with them their own recommendations. But it may not be wholly superfluous, by way of summing up, to specify the suggestions to which the facts seem to give rise in a more succinct form.

1. It seems desirable that the portion of country covered by this report—at least all that falls within the designation of petrified forests—be withdrawn from entry at once, pending further steps in the matter. The amount withdrawn might be considerably larger than that included in the boundaries above specified, in order that no important feature shall be excluded from the tract finally embraced in the park. At present, so far as I could learn, there is only one claim filed on the entire area. This is a claim to a quarter section in the upper forest, filed by Mr. Adam Hanna. At the time that it was proposed to manufacture emery out of the silicified wood several other claims were filed, but, on the failure of the scheme, they were abandoned. Several horse herders have located on the arroyo, or creek, in the center of the lower or principal forest, and have erected a cabin there, but I understand that they have filed no claims and are there merely by sufferance. They are, however, doing no damage to the forests.

2. There is needed a more extended and accurate survey than I was able to make of the proper boundaries of the park. The survey should be made in part by geologists and vegetable paleontologists, in

order that due weight be given to scientific considerations—such, for example, as that of causing the park to include points at which the fossil logs are actually in place and good exposures of the rock in which they are embedded.

3. The area fixed upon by this survey should be correctly described and made a public reserve by act of Congress, with proper provisions for its preservation. I need not further specify what I think these provisions should be. Those of other similar acts, with special modifications to suit the case, will probably suffice.

4. As early as possible after the boundaries shall have been fixed there should be made a new topographical survey, which need not, however, be limited to this area, but should include it. The topographic map resulting from this survey should be on a scale of 1 mile to the inch and the contour interval should be 50 feet. The parties making the survey should be instructed to give appropriate names to all the more prominent objects and features, and to locate and name them on the map for the future use of the public visiting the park. A geological map should also be prepared on this new base. The present topographic map, on a scale of 4 miles to the inch, with a contour interval of 250 feet, is very inconvenient, and of little value in the study of this region.

5. No time should be lost in taking measures to prevent the parting and collapse of the natural bridge. As I have shown, this is liable to occur at any time; and although it may last for hundreds of years, still the danger that it may give way, and thus ruin the most important feature of the park, justifies prompt attention. Engineers should at least examine it at once, and if they find it insecure, as stated, they should take steps to strengthen it and render it permanent, which could probably be done at little expense.

As the land on which the natural bridge is located is public land, this work might be done independently of any action in the direction of making it a public reserve, but it seems doubtful whether the authorities could be brought to the point of actually taking action in the matter unless attention be first concentrated upon it by such an act as that of creating a public reservation. But if steps in this direction could be taken in advance of such action, this would diminish the chances of the catastrophe.

I have the honor to be, very respectfully, yours,

LESTER F. WARD,

Paleontologist, United States Geological Survey.

Hon. CHARLES D. WALCOTT,

Director United States Geological Survey.

